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CCP2 Storage Program: Well Integrity Field Program, Certification Framework and Other Assurance Studies

Regional Carbon Sequestration Partnerships Review Mtg.
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Presentation Outline

CCP2 Storage Monitoring & Verification (SMV) Team

Current Gaps / Opportunities in CO2 Storage

CCP2-SMV Projects
- Primary
  - Certification Framework
  - Well Integrity Field Study
- Additional (Coupled Simulation, ECBM, Remote Sensing; Well Logging)

How can CCP work with the RCSPs?
- Phase 2
- Phase 3

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The CCP2 Storage Monitoring & Verification (SMV) Team

BP	
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- Dan Ebrom	Geophysics
- Venkataramanan Muralidharan	Resv. Engr.
Chevron	
- Scott Imbus (Lead)	Geochemistry
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- Chip Feazel	Geology
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- Antonio Pellegrino	Resv. Engr.

Hydro	
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Repsol	
- Martin Fasola	Geology
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- Nigel Jenvey	Petr. Engr.
- Jos Maas	Resv. Engr.
Suncor	
- Cal Coulter	Resv. Engr.

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Current Gaps / Opportunities in CO2 Storage (1)

Containment

- Geologic system evaluation is key but is there anything we can do that is more systematic, quantitative and understood by stakeholders?
- Wells seem OK from decades-long EOR experience but lab exposed cements dissolve in weeks. What will be the case with long term storage?
- What do we know about containment in saline formation seals or “open” systems?

Optimization

- Migration / trapping simulations are becoming more sophisticated and based on real systems. Do they need experimental verification?
- For EHR: Is there merit in WAG EOR alternatives? Is EGR possible? What is the real promise of ECBM?

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Current Gaps / Opportunities in CO2 Storage (2)

Monitoring

- What is the potential if i-Well and i-Field technology for sampling / sensing injection reservoirs, wells, potable aquifers and the near surface?
- Should monitoring technology / protocols be standardized or "fit-for-purpose"?
- Should monitoring requirements be open-ended or based on performance criteria?

Risk Assessment (RA)

- Major applications have become unwieldy and too complex. Is it possible to streamline the process and make it useful to stakeholders?
- What are the appropriate analogs (e.g., arctic or deepwater drilling) and benchmarking criteria?

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CCP2-SMV Projects

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Certification Framework - Background

Existing Site Assessment Approaches
- Characterize the system (depth, lithology, fluids, processes, events, impacts)
- Develop model of the system (site-specific coupled-process model)
- Make projection of future behavior
  - Run the model(s) for various scenarios
  - Observe impacts
- Calculate risk as product of impact and probability

Critique
- Site assessment, reservoir simulation and risk assessment are complex, poorly integrated and not benchmarked
- Methodologies do not appear to parallel or intersect existing regulatory frameworks (e.g., UIC)
- We have yet to arrive at a simple, transparent process acceptable to stakeholders

Large scale, widespread CCS is unlikely to occur if operator is without a manageable and predictable "certification process" based on performance criteria (as opposed to standardized, open-ended monitoring requirements and unlimited long-term liability)

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Certification Framework - Scope

A simple, transparent, and accepted basis for regulators and stakeholders to certify that the risks of geologic CCS projects to HSE and resources are acceptable is critical to the wide scale deployment of CCS
PIs: **LBNL (C. Oldenburg) / UT-Austin (S. Bryant)**

Approach
- Streamlined and integrated platform for site characterization, reservoir simulation of injection strategies, modeling leakage scenarios, life cycle risk calculation
- Criteria established injection and abandonment "certification" (predicted and actual performance, respectively.)
- Acceptability -Understandable, defensible, expert and stakeholder advice, demonstration

Status
- Definitions and scope detailed
- Generic reservoir framework established
- Advisory board (AB) comprised of NGOs, regulators, industry and technical experts confirmed (First teleconference 9/25)

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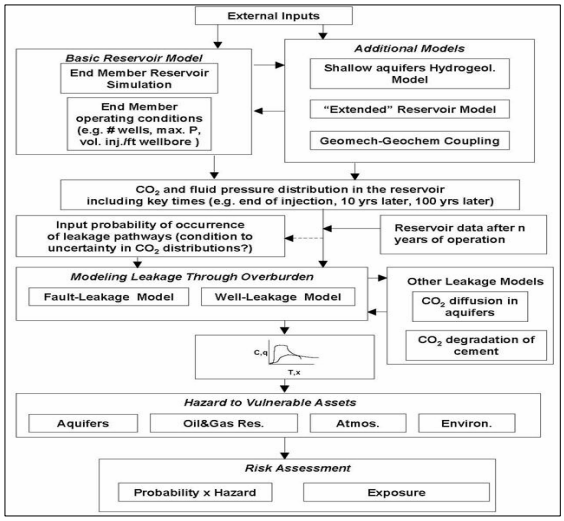
Certification Framework - Schema



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Well Integrity Field Study - Background

- Wellbore integrity widely recognized as the premier CO_2 storage containment issue thus a potential show-stopper in depleted oil and gas field venues.
- CO_2 well failures have been documented
  - Waste disposal wells (Lehr, 1986)
  - CO_2 EOR (Skinner, 2003)
- The EPA UIC program is credited with absence of significant failures of waste disposal wells (Tsang et al., 2001)
- Research to date has focused development / testing of resistant materials
  - CCP2 (Sintef / IFE)
  - CMI
  - Schlumberger & Halliburton
- Successful field study on Kinder-Morgan SACROC by LANL presented at 2005 WBI Workshop

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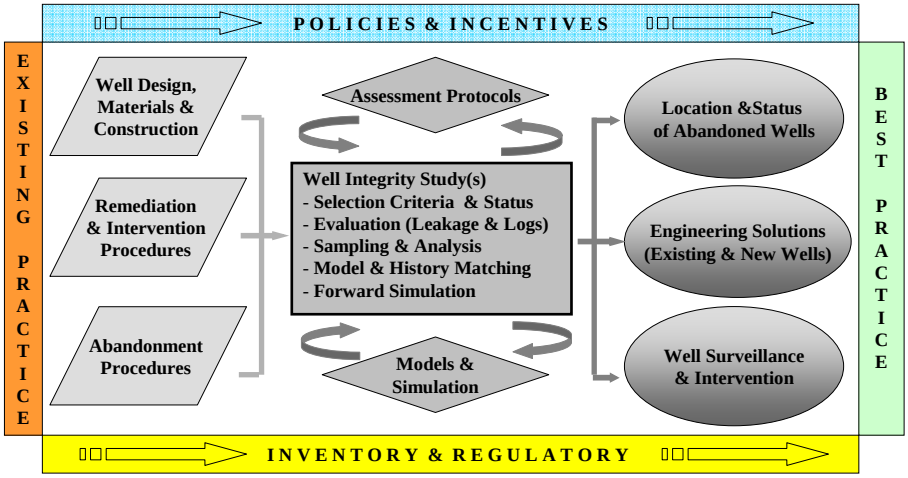
Comprehensive Well Integrity Program



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Well Integrity Field Study - Scope

Field-based study to realistically assess CO2-experienced well status, history match well "defects" with production / work over data and simulate well survivability over an extended time period under CO2-rich conditions (Schlumberger; others TBD)

Major Tasks Include:

- Well selection & evaluation
- Well sampling, analyses & experiments
- Model construction with history match
- Forward simulation
- Engineering solutions

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Well Selection & Evaluation

Basic Criteria:

- Clastic reservoir and cap rock
- Well CO_2 experience (production vs. injection) and disposition
- Operator access, facilitation and assumption of abandonment costs
- Records (design, materials, injection/ production, integrity testing, workovers)
- Nature of injected / produced fluids (injector vs. producer or mixed; CO_2 humidity & purity, oil & gas)
- Condition of well (altered but not destroyed)
  - Well logging (CBT, USIT/MSIP) and integrity testing
  - Recent solids or fluid samples (swc, cased hole RFT)
  - Pressure and tracer testing

An initial well assessment with sampling is presently underway at BP's Sheep Mtn. production facility (Colorado)

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Well Sampling, Analysis & Experiments

Sample locations based on well log imaging to detect and map altered / non-altered zones

Sampling of altered and non altered zones + pattern

- RFTs & SWCs (fluid only?)*
- Whipstock coring (casing, cement & country rock)
- Other sampling techniques?

Sample Analysis (using screening protocol w/ unaltered samples as baselines)

- Solids (petrography-SEM & mineralogy, petrophysics, Xray-CT, mechanics)
- Fluids
  - Oil & Gas (typing)
  - Water (pH, TDS, alkalinity, ionic, elemental, stable isotopes)

Experiments

- Water-solid (casing, cement & country rock) equilibrium w/ analyses

** Can cement alteration status be inferred from fluid chemistry?*

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Modeling & Simulation

Modeling
- Classification and mapping of “defects”
- Qualitative reconstruction of alteration history with production / work over records

Simulation
- Quantitative reconstruction of alteration history
- Variability of alteration under end member injection / production scenarios
- Using analytical, experimental and model data, forward simulate well alteration to X years under end member abandonment and fluid exposure scenarios

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Engineering Solutions

Based the well integrity study findings, what steps can be taken to avoid well failure? (Workshop Approach)

Design
- Materials and construction that would prevent types of “defects”
- Certification criteria for installation, operation and abandonment

Remediation
- Well evaluation tools and well condition classification
- Novel, inexpensive approaches

Intervention
- In situ and external monitoring tools
- Design considerations for well access
- Novel, inexpensive approaches

Description of an ideal well capable of survival to X years

Reliability standards and risk assessment?

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CCP2-SMV Additional Projects

Coupled Geochemical-Geomechanical Simulation - Improve and integrate existing simulation programs to more accurately predict fluid – rock response to CO2 injection and its impact on containment system integrity (U Bergen)

ECBM Operability and Monitoring -Simulation of operational limits for CO2 ECBM injection strategies and feasibility of geophysical monitoring for performance and leakage from the coal reservoir and associated rock system (Sproule Associates / LBL)
- Currently stalled due switch of venue and TP reorganization
- Will test against an Alabama Coal

Remote, Aerial Direct Detection of CO2 and Methane – Identify, tune and test a sensor capable of detecting CO2 and methane (UCSC).
- NASA MASTR sensor selected and tuned
- Overflight over controlled CO2 / methane release; Results pending

In-Situ Well-Based Detection of CO2 – Proof of concept conventional logging tools can detect small quantities of CO2 leaking into an accumulation chamber (Schlumberger)
- Large test cell constructed and tested at reservoir conditions
- Test cell charged with sediment and brine and charged with CO2
- Logging tool (RST) was capable of detecting CO2 in sigma (but not IC) mode

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Prospective CCP2-SMV Expansion or CCP2-SMV Projects

Existing
- Certification Framework - acceleration, expansion (new tasks) or application development
- Well Integrity Field Study – cover contingencies, new tasks, additional case study

Under Consideration for CCP3 (2008-2012)
- Saline Formations – systematize characterization, trapping, seals; Joint field pilot
- CO2 EOR – Alternative flooding techniques to optimize recovery / storage; Heavy Oils
- CO2 EGR – As pressure support and solvent
- Remote, Automated Detection and Sensing – Adaptation of iField / iWell applications
- Several others

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How Could CCP2 (Phase 3) Work with the RCSPs (Phase 3)?

- Provision of "Certification Framework" for demonstration candidates
- Lead or co-lead a "Saline Formations" JIP that includes RCSP demonstration sites
- Apply simulations for well stability
- Targeted studies in optimization of EHR and storage
- Applicability of i-Well / i-Field monitoring technologies
- Experimental calibration of subsurface processes (e.g., capillary trapping)